CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

Nuclear materials production operations at the Savannah River Site (SRS) (Figure 1-1) resulted in the generation of large quantities of **high-level radioactive waste** (referred to as high-level waste or HLW). This waste has been stored onsite in large underground tanks. The U.S. Department of Energy (DOE) built the Defense Waste Processing Facility (DWPF) to convert this HLW to a stable glass form suitable for disposal in a geologic repository. The DWPF has been operating since 1996 to **vitrify** (i.e., convert to glass) one of the **HLW components**.

> To assist the reader in understanding technical terms specific to the proposal action, those terms have been **bolded** the first time they are used and are discussed in Table 1-1, Primer of Technical Terms, located at the end of this chapter. Additional technical terms are located in the Glossary.

SRS HLW was generated as an acidic solution, then was chemically converted to an alkaline solution for storage. In its alkaline form, it consists of two components, soluble **salt** and insoluble **sludge**. Both components contain highly radioactive residues from nuclear materials production. **Radionuclides** found in the sludge include **fission products** (such as strontium-90) and long-lived **actinides** (such as uranium and plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides.

Dewatering the salt solution by evaporation, a process that conserves tank space, converts the salt solution to a solid **saltcake** and a concentrated **salt supernatant**. The saltcake must be converted back to salt solution to process the salt component by any action alternative described in this SEIS. Solid saltcake would be dissolved by adding water and combined with salt supernatant to form a salt solution. An L6-10

Radionuclides

Cesium (Cs)

Cesium-137 (half-life 30 years), Cs-135 (half-life 21.3 million years), and Cs-134 (half-life 2 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Plutonium (Pu)

Plutonium is a man-made, radioactive element in the actinide series. Pu-238 (half-life 88 years) and -239 (half-life 24,000 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Strontium (Sr)

Strontium-90 (half-life 29 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Technetium (Tc)

Technetium is a man-made, radioactive element. Tc-99 (half-life 200,000 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Uranium (U)

Uranium is a long-lived radioactive element in the actinide series. U-235 (half-life 700 million years) and U-238 (half-life 4 billion years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

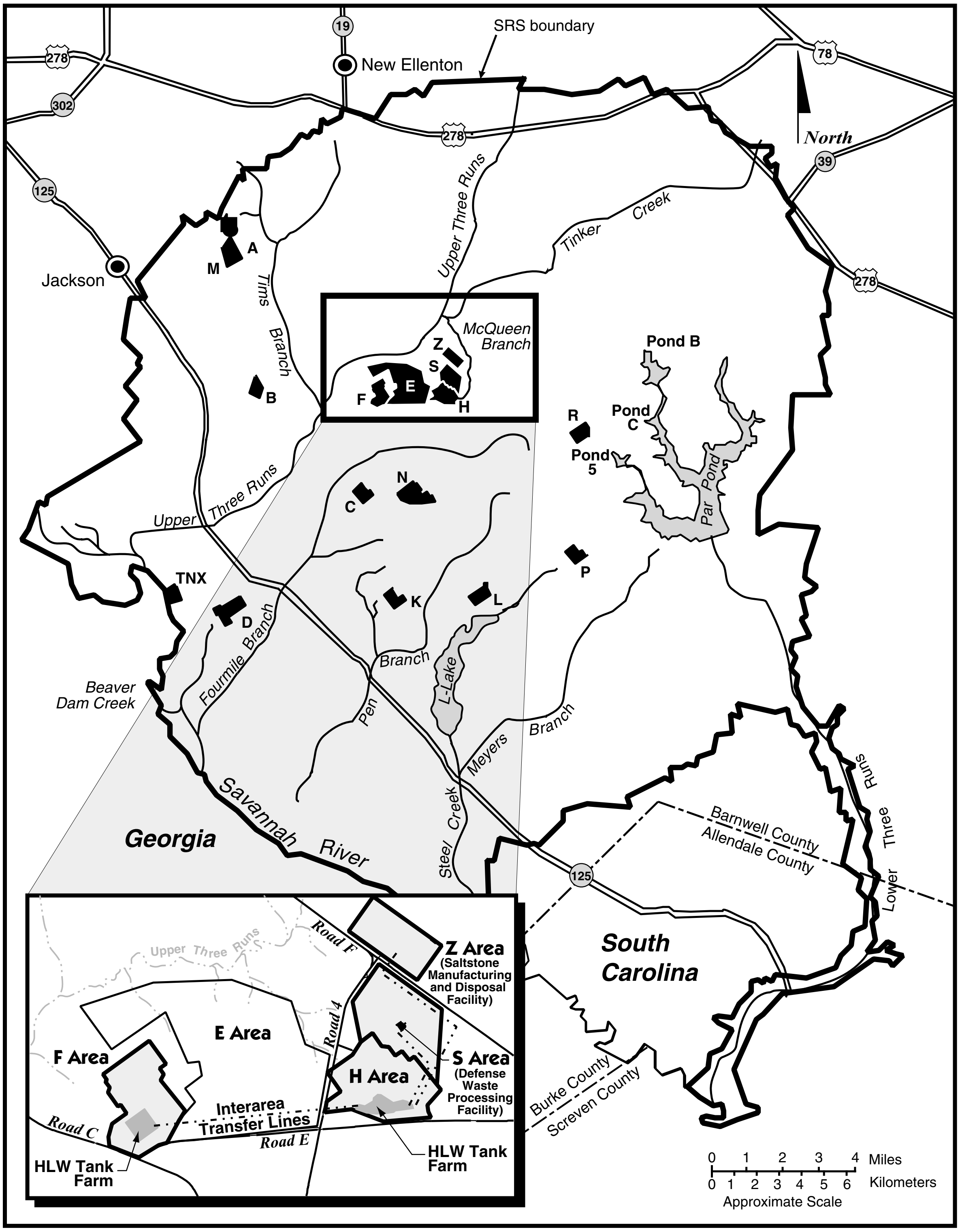

Figure 1-1. Savannah River Site map with F, H, S, and Z Areas highlighted.

important part of the system would then separate the highly radioactive constituents from the salt solution.

The high-activity fraction removed from salt solution would be vitrified in DWPF, and the less radioactive constituents, still in the salt solution, would be stabilized with grout (a cement-like mixture), to create a saltstone waste form for onsite disposal as **low-level radioactive waste (LLW)**.

DOE evaluated the potential impacts of constructing and operating DWPF in a 1982 environmental impact statement (EIS) (DOE 1982). In 1994, DOE published a Supplemental EIS (SEIS) (DOE 1994) evaluating changes in the process proposed after the 1982 EIS was issued. The Record of Decision (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of DWPF.

The process DOE selected in 1994 to separate the high-activity fraction from the salt solution is known as In-Tank Precipitation (ITP). This process was designed to be carried out primarily in one of the underground HLW storage tanks with a 1.3-million-gallon capacity. An inorganic **sorbent**, **monosodium titanate**, would remove actinides and radioactive strontium from the salt solution. An organic **reagent**, **sodium tetraphenylborate**, would precipitate radioactive cesium from the salt solution. The ITP TC process included washing and filtration steps to separate the resulting solids and residual sludge for vitrification in DWPF.

The reagent used to precipitate cesium in the ITP process, tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. This decomposition returns the cesium to the salt solution, and generates **benzene**. Benzene is a toxic, flammable, and potentially explosive organic substance that must be safely controlled.

To achieve the objectives of the ITP process, the decomposition of tetraphenylborate must be limited to minimize (1) the amount of precipitated cesium that is redissolved in the salt solution, and (2) the amount of benzene generated. The ITP process was designed to accommodate some tetraphenylborate decomposition and to limit benzene accumulation. Startup testing of the ITP facility in 1995 generated benzene in much greater quantities than had been anticipated based on calculations and laboratory experiments and ITP startup operations were suspended in order to develop a better understanding of the ITP process chemistry. L1-2

In August 1996, the Defense Nuclear Facilities Safety Board (DNFSB), an independent oversight board chartered by Congress to review operations at DOE nuclear defense facilities and make recommendations necessary to protect public health and safety, recommended that planned large-scale testing of the ITP process not proceed further until DOE had a better understanding of how benzene was generated and L6-12 released during the **precipitation** process (DNFSB 1996). In response to the DNFSB recommendation, DOE initiated an extensive chemistry program to better understand the benzene generation and releases. L6-12 In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements, that is, the satisfactory separation of radionuclides from HLW salt solution without excessive tetraphenylborate decomposition. L6-13 DOE must therefore select an alternative technology for HLW salt processing. DWPF continues to process and vitrify HLW sludge without including the high-activity fraction of the HLW salt component. About 1,100 sludge-only canisters had been processed through May 2001. L1-3

Westinghouse Savannah River Company (WSRC), the SRS operating contractor, recommended to DOE that a systematic evaluation be conducted to identify viable salt treatment technologies to replace the ITP process (DOE 1998a). This evaluation was done and, in October 1998, WSRC presented its recommendation of alternatives to DOE (WSRC 1998). WSRC recommended four technologies for further consideration: Small Tank **Tetraphenylborate Precipitation**, **Crystalline Silicotitanate Ion Exchange**, **Caustic Side Solvent Extraction**, and **Direct Disposal in Grout**. In early 1999,

The High-Level Waste Management System

The HLW management system at SRS comprises seven interconnected operations as follows:

- HLW storage (in underground storage tanks) and evaporation in the F- and H-Area Tank Farms
- Sludge processing in the Extended Sludge Processing Facility
- Salt processing using the ITP process, including the Late Wash Facilities (inactive, as described in the text)
- HLW vitrification in DWPF
- Solidification of low-activity salt solution in the Saltstone Manufacturing and Disposal Facility
- Wastewater treatment in the Effluent Treatment Facility
- Organic destruction in the Consolidated Incineration Facility (CIF) (inactive, as described in the text)

The HLW management system is currently operating, except for salt processing through ITP and the Late Wash Facility, and CIF. ITP operations are now limited to facility surveillance and maintenance. The Late Wash Facility has been tested, using nonradioactive materials, and is in standby status. The CIF was constructed to incinerate benzene generated in the ITP process and to destroy plutonium/uranium extraction (PUREX) solvent wastes from chemical separations operations, solid LLW from ongoing operations, and waste from decontamination and decommissioning projects. CIF operations were suspended in October 2000. DOE expects to make a decision on whether to resume CIF operations by April 2002. DOE is investigating alternatives to incineration and will not operate the CIF if an effective alternative disposal for PUREX solvents can be identified. TC

based upon review of the recommendation by DOE and independent reviewers, DOE decided to pursue three of the four candidate alternatives for replacement of the ITP process.

Solvent Extraction was dropped from consideration in 1999 because it was considered technically immature. DOE restored Solvent Extraction to the list of potential alternatives in February 2000 (DOE 2000a), based on recommendations from the National Academy of Sciences (NAS 1999) and new research and development results. A description of DOE's salt processing program, including results of research and development, may be found on the Internet at www.srs.gov/general/srtech/spp/randd.htm.

In parallel with development of the WSRC recommendations on alternative technologies, DOE prepared a Supplement Analysis (DOE 1998b) in accordance with the Department's National Environmental Policy Act (NEPA) regulations (10 CFR 1021). Based on the Supplement Analysis, DOE decided to prepare this second SEIS on DWPF and its supporting processes because necessary additional technical changes will significantly alter the way in which HLW salt is processed from that described in the original EIS and the 1994 SEIS. This second SEIS evaluates the potential environmental impacts of replacing the ITP process for salt processing with an alternative technology. The SEIS also considers the impacts of a No Action alternative.

1.2 Purpose and Need for Action

The ability to safely process the salt component of the HLW stored in underground storage tanks at SRS is a crucial prerequisite for completing HLW disposal. Without a suitable method for salt management, DOE would not be able to place the HLW in a configuration acceptable for safe disposal. Thus, DOE must identify and implement one or more technologies to prepare the SRS HLW salt component for disposal. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of LLW at SRS. If salt processing is delayed beyond 2010, DOE recognizes that the salt waste must be vitrified separately from the sludge component of the

HLW, and the total number of HLW canisters would be increased over that projected for concurrent sludge and salt waste vitrification.

Preliminary projections indicate that, if the salt processing date of 2010 is not met, then the potential exists that up to 150 additional canisters (salt-only) per year would have to be produced for every year startup is delayed beyond 2010. The cost for additional
L1-5 canister production would be about
L6-16 $300 million per year. In the event that
L6-44 sludge processing was to be completed prior to the initiation of salt processing, it would take 13 years (at 150 canisters per year) to process all of the salt waste at an approximate cost of $4 billion in addition to the cost of constructing and operating the salt processing facility. (Note: These costs do not include Federal Repository costs for transportation and disposal).

HLW Tank Closure Activities

DOE, the U.S. Environmental Protection Agency (EPA), and the South Carolina Department of Health and Environmental Control (SCDHEC) have agreed to a schedule for closure of the Savannah River Site HLW tanks. DOE must close the tanks in accordance with applicable laws, regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996). Bulk waste must be removed from the tanks before closure can begin. Without a salt processing alternative, and with continued sludge-only vitrification in the DWPF, HLW storage requirements will be such that DOE may not be able to empty all tanks and, therefore, after about 2010, tank closure commitments may not be met. DOE has prepared the *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, to evaluate the impacts of the tank closure program (DOE 2000b).

1.3 SEIS Overview

1.3.1 SCOPE

In accordance with Council on Environmental Quality (CEQ) requirements, DOE is integrating the NEPA analysis early in the planning process to ensure that environmental values are considered in decision making (40 CFR 1501.2). This SEIS describes the technology alternatives that DOE is considering to replace the ITP technology for salt processing. Processes and facilities that would be needed for each alternative are presented. The SEIS also estimates the environmental impacts that could result from the construction and operations associated with each of the alternatives, based on information from **preconceptual facility designs** for the action alternatives and other information developed specifically for the SEIS. For each alternative, the impacts to the environment and human health from normal facility operation and from accidents that might occur during operation are estimated and presented in the SEIS.

In addition, the SEIS describes the potential impacts of a No Action alternative, as required by NEPA. The impacts of the No Action alternative provide a basis for comparison with the impacts of the action alternatives. The No Action alternative is defined as the continuation of actions DOE has already taken or is currently taking. As such, No Action could be defined as operation of the ITP Facility for salt processing, as projected in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility Record of Decision* (60 FR 18589 – 18594; April 12, 1995). However, because DOE has determined that the ITP process cannot achieve both safety and production requirements, it will not be operated. A comparison of the impacts of the alternatives to the operation of the ITP Facility would not, therefore, prove meaningful. Consequently, DOE has defined No Action as a continuation of current HLW management activities, including tank space management, and vitrification of the sludge component of HLW, without operation of the ITP Facility. See Chapter 2 for a full explanation of the No Action alternative.

Decisions to be Made

TC

DOE has completed this SEIS and related technical studies, and has selected caustic side solvent extraction as the preferred alternative. No sooner than 30 days after EPA publishes a Notice of Availability of the SEIS, DOE will select a salt processing technology and issue a Record of Decision (ROD). DOE may construct and operate a Pilot Plant for the selected technology and then produce a **final design** of the facility that would implement full-scale operation of the selected technology.

1.3.2 ORGANIZATION

DOE has prepared this SEIS in accordance with the NEPA regulations of the CEQ (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021). This SEIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, results available from ongoing studies are incorporated directly or are summarized and referenced. The organization of the SEIS is as follows:

- Chapter 1 describes the background and purpose and need for DOE action regarding salt processing at SRS.
- Chapter 2 describes the proposed action and the alternatives that DOE is evaluating.
- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives.
- Chapter 5 discusses the cumulative impacts of salt processing in relation to other past, present, and reasonably foreseeable future activities at SRS, and in the surrounding region.
- Chapter 6 identifies irreversible and irretrievable resource commitments.
- Chapter 7 discusses applicable statutes, state and Federal regulations, DOE Orders, and agreements.

The appendices provide more detailed discussions of certain topics. Appendix A describes the facilities that would be used for each of the alternatives. Appendix B describes the methods used for accident analysis and results of the analysis. Appendix C presents the public comments received on the draft SEIS, and DOE's responses to those comments. Appendix D gives the methods, concentrations, doses, and results of long-term performance modeling used to evaluate the long-term impacts of salt processing alternatives. Corresponding health effects are given in Section 4.3 of Chapter 4.

1.3.3 STAKEHOLDER PARTICIPATION

On February 22, 1999, DOE announced in the *Federal Register* its intent to prepare a *Supplemental Environmental Impact Statement for Alternatives to the In-Tank Precipitation Process* (64 FR 8558). To more accurately describe the process, DOE has since retitled this document as the Salt Processing Alternatives SEIS.

A Notice of Availability for the Draft SEIS was published in the Federal Register on March 30, 2001 (66 FR 17423). Public meetings to discuss and receive comments on the Draft SEIS were held at the North Augusta Community Center in North Augusta, South Carolina, on May 1, 2001, TC
and at the Holiday Inn Coliseum in Columbia, South Carolina, on May 3, 2001. The public comment period ended May 14, 2001. In the public meetings nine individuals commented on the Draft SEIS. During the 45-day comment period DOE received 12 letters commenting on

the Draft SEIS. The comments addressed four broad issues:

- No Action alternative
- Direct Disposal in Grout alternative
- Waste management
- Criteria for the selection of the preferred alternative

Appendix C presents the comments received on the draft SEIS and DOE's responses to those comments.

The National Academy of Sciences - National Research Council Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site was given the opportunity to comment on this Final SEIS. The Committee chose not to comment on the Final SEIS, but instead to comment on separation alternatives in its report to DOE, which was submitted on June 4, 2001 (see Section 1.4.2).

1.4 Related Information

This SEIS makes use of information contained in other DOE NEPA documents related to HLW management. It is consistent with DOE's parallel EIS process on HLW tank closure at SRS, which is related to activities in the F- and H-Area Tank Farms. The NEPA documents pertaining to this Salt Processing Alternatives SEIS are briefly described below.

1.4.1 NEPA DOCUMENTS

Final Environmental Impact Statement, Defense Waste Processing Facility (DOE 1982)

DOE prepared this EIS to address the potential impacts of constructing and operating DWPF to vitrify HLW in preparation for final disposal in a monitored geologic repository. DOE announced its decision to construct and operate DWPF in a ROD published in the *Federal Register* (47 FR 23801) on June 1, 1982.

Final Environmental Impact Statement, Waste Management Activities for Groundwater Protection (DOE 1987)

DOE prepared this EIS to address the potential environmental impacts of **hazardous waste**, LLW, and **mixed waste** management activities that could affect the groundwater resources under and near SRS. On March 9, 1988, DOE decided (53 FR 7557) that LLW generated by each alternative would be disposed of in vaults on the SRS. Disposal has to meet SRS waste disposal performance assessment criteria that are imposed to protect groundwater.

Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility (DOE 1994)

DOE prepared an SEIS to examine the impacts of completing construction and operating DWPF at SRS. This document assisted the Department in deciding whether and how to proceed with the DWPF project, given the changes to processes and facilities that had occurred since 1982, when DOE issued the original DWPF EIS. The evaluation in the EIS included short- and long-term impacts associated with the construction and operation of the Saltstone Manufacturing and Disposal Facility and disposal vaults.

On April 12, 1995, the ROD (60 FR 18589) announced that DOE would complete the construction and startup testing of DWPF, and would use ITP for salt processing, after satisfactory completion of its startup testing. The ROD also announced that the low-activity salt solution resulting from salt pretreatment would be immobilized in the Saltstone Manufacturing and Disposal Facility and permanently disposed of in the Z-Area vaults. DOE has now determined that the ITP process cannot meet safety requirements and production goals and is therefore pursuing alternative technologies for HLW salt processing.

Final Environmental Impact Statement, Waste Management (DOE 1995)

DOE issued the SRS Waste Management EIS (DOE 1995) to provide a basis for the selection of a Sitewide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The SRS Waste Management EIS included the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area Tank Farm operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the CIF for the treatment of mixed waste, including incineration of benzene waste from the then-planned ITP process. The first ROD (60 FR 55249) on October 30, 1995, stated that DOE would configure its waste management system according to the moderate treatment alternative described in the EIS. The SRS Waste Management EIS is relevant to this Salt Processing Alternatives SEIS because it evaluates management alternatives for various types of waste that actions proposed in this SEIS could generate. The Waste Management EIS is also relevant to the assessment of cumulative impacts that could occur at SRS. The second ROD (62 FR 27241) was published on May 19, 1997, to ensure consistency with the *Approved Site Treatment Plan* (WSRC 1996) and also to announce DOE's decision to construct and operate additional facilities at SRS for characterization and treatment of mixed waste.

Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options (DOE 1998b)

DOE prepared a Supplement Analysis that led to a determination to prepare this SEIS. The Supplement Analysis provides a description and comparison of the impacts of the ITP facility with the proposed salt processing alternatives that DOE was considering in 1998.

Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE 2000b)

On December 29, 1998, DOE published a Notice of Intent to prepare an EIS on closure of HLW tanks at SRS (63 FR 71628). The Draft EIS, issued in November 2000, examines the impacts of closing the SRS HLW tanks in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996) approved by the South Carolina Department of Health and Environmental Control. The proposed action would begin on a tank-by-tank basis after bulk waste removal has been completed. Under each alternative, except No Action, DOE would close 49 HLW tanks and associated waste handling equipment, including evaporators, pumps, diversion boxes, and transfer lines. The preferred alternative consists of cleaning the tanks with water and filling them with grout. If necessary to meet performance requirements, additional cleaning (e.g., with oxalic acid) could be performed. The use of sand or saltstone as fill material was also considered. The EIS considers a No Action alternative that would consist of leaving the tank system in place after bulk waste removal. The comment period for the Draft EIS ended on January 23, 2001. Publication of the Final EIS is tentatively planned for Summer 2001.

1.4.2 OTHER RELEVANT DOCUMENTS

High-Level Waste Salt Disposition Systems Engineering Team Final Report (WSRC 1998)

This report describes the technology selection process that WSRC used to evaluate the final four technologies recommended to DOE for replacement of the ITP process.

Nuclear Waste – Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work (GAO 1999)

At the request of Congress, the General Accounting Office reviewed the reasons the ITP process did not work. This report describes the history of developing the ITP process and of selecting a replacement salt processing technology. The General Accounting Office concluded that the "Department and Westinghouse have taken steps that, if fully implemented, should better ensure a successful alternative."

Savannah River Site High-Level Waste Tank Space Management Team Final Report (WSRC 1999a)

This report identifies a strategy (including the potential operation of a new HLW evaporator in DWPF) for managing liquid HLW to ensure that existing SRS HLW tanks provide sufficient storage and processing capacity pending startup of a replacement process for ITP.

High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report (WSRC 1999b)

This report describes the process used to recommend a path forward for salt processing at the SRS. The report identifies programmatic risks, estimated costs, and project implementation schedules developed for the candidate technologies. The document recommended best-suited and backup technologies.

Defense Nuclear Facilities Safety Board Recommendation 96-1 to the Secretary of Energy (DNFSB 1996)

The DNFSB review of planned use of tetraphenylborate (TPB) in the ITP process to remove radioactive cesium from SRS HLW salt solutions conveyed concern over the rate of TPB decomposition and mechanisms for holdup and release of benzene encountered in large-scale tests using actual HLW. The DNFSB recommended deferral of additional tests involving large quantities of HLW pending: (1) improved understanding of the causes and mechanisms of benzene generation, retention, and release and (2) additional investigation to establish identification and role of **catalysts** involved in the TPB decomposition, and the factors controlling benzene retention and release. DNFSB concluded that such measures were necessary to ensure adequacy of existing safety requirement and to devise new safety and operational constraints.

NAS Review Committee Final Reports (NAS 2000, 2001)

In June 1999, the Under Secretary of Energy requested that the National Academy of Sciences – National Research Council provide an independent technical review of alternatives for processing the HLW salt solutions at the SRS. In response to the request, the Council appointed a "Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site" to review DOE's work to identify alternatives for separating cesium for high-level waste at the Savannah River Site. This committee conducted the review and provided an interim report in October 1999 and a final report in October 2000 (NAS 2000). In October 2000, the Council appointed a "Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site" to review DOE's efforts to evaluate and select a process for separating radionuclides for soluble high-level radioactive waste at the Savannah River Site. This second committee conducted their review and provided an interim report in March 2001 (NAS 2001a) and a Final Report in June 2001 (NAS 2001b). Summaries of the reviews conducted by these Council committees are provided in Section 2.8. TC

Defense Nuclear Facilities Safety Board Recommendation 2001-1 to the Secretary of Energy (DNFSB 2001)

A recent survey of SRS radioactive HLW management operations by the DNFSB addressed emergency problems in handling and storage of liquid wastes due to the projected shortage of HLW tank space. The survey resulted in recommendations to implement several measures to maintain adequate safety margins in HLW TC

TC storage, including the reassessment and vigorous acceleration of the schedule for operation of a salt processing facility. Developing an integrated plan for tank space management to maintain safe operating margins pending startup of salt waste processing was recommended. Measures proposed, analogous to those projected for the No Action alternative in the SEIS, included reducing or eliminating the DWPF low-level liquid waste stream, recovering ITP process tanks for waste storage, resolving existing HLW evaporator problems and assessing the need for additional evaporator capacity, and possibly constructing additional waste tanks. The DNFSB recognized that implementation of such measures is in progress, but urged special focus to avoid delays that could result in reduced safety. TC

DOE and the DNFSB are discussing the elements of an implementation plan that would be acceptable to the Board.

Table 1-1. Primer of Technical Terms (other scientific terms are defined in the glossary to this SEIS).[a]

Actinide
Any member of the group of elements with atomic numbers from 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive.

Benzene
Benzene, the simplest aromatic hydrocarbon, is widely used in industry. The chemical formula for benzene is C_6H_6. Benzene is a toxic, flammable, and potentially explosive substance that must be safely controlled. It is generated by the catalytic and radiolytic decomposition of the reagent tetraphenylborate, formerly used in the In-Tank Precipitation process and currently projected for use in the Small Tank Precipitation salt processing alternative.

Catalyst
A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process.

Catalytic decomposition
A chemical reaction in which a compound is broken down into simpler compounds of elements is the presence of a catalyst.

Caustic
An alkaline solution containing sodium hydroxide in other light metal oxides. SRS HLW solutions are caustic solutions.

Caustic Side Solvent Extraction
A technology alternative for processing the HLW salt solution to remove radioactive cesium by transfer to an immiscible organic stream, from which it is recovered into a secondary aqueous stream for vitrification at the Defense Waste Processing Facility. Before the cesium is removed from the salt solution, radioactive strontium and actinides are removed by sorption onto monosodium titanate and vitrified in DWPF. The remaining low-activity salt stream is immobilized in grout and disposed of as saltstone in onsite vaults.

Crystalline silicotitanate
Insoluble granular inorganic solid ($Na_4SiO_4 \bullet TiO_2$) ion exchange material developed through a cooperative research and development agreement between DOE and private industry. Provides capability for removing cesium from acid or alkaline salt solutions containing high sodium potassium concentrations. **Crystalline** refers to being, relating to, or composed of crystals.

Crystalline Silicotitanate Ion Exchange
A technology alternative for processing HLW salt solution to remove radioactive cesium by absorption onto a siliconate ion exchange resin that would be incorporated into a glass waste form by vitrification in the Defense Waste Processing Facility (see Ion Exchange).

Decomposition
The process by which a compound is broken down into simpler compounds or elements by chemical or physical reactions.

Direct Disposal in Grout
A technology alternative for processing the HLW salt solution without removal of radioactive cesium by immobilization in grout for onsite disposal as saltstone. Radioactive strontium and actinides are removed prior to disposal and vitrified in DWPF.

Table 1-1. (Continued).

Final design
In the final design phase, the emphasis has shifted almost completely from the qualitative aspects of the process to the quantitative. Major process vessels are sized and initial valve counts are often completed. By the end of this phase, a preliminary piping and instrumentation diagram typically will be complete, and broad considerations of facility site design will have been concluded. Opportunities for major process changes are few at this stage, but preliminary cost estimates (on the order of +/- 30%) and economic analyses can be produced.

Fission product
Nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by radioactive decay of the fission fragments.

High-level radioactive waste (HLW)
Based on the statutory definition in the Atomic Energy Act (which references back to the Nuclear Waste Policy Act for the definition of "high-level radioactive waste" and "spent nuclear fuel"), HLW is defined by DOE to mean the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation. DOE has not defined "sufficient concentration" of fission products or identified "other highly radioactive material that requires permanent isolation."

HLW components
The HLW from the SRS chemical separations process consists of water soluble salts and insoluble sludges. The sludges settle to the bottom of the HLW tanks. The salt solutions are concentrated by evaporation to reduce their volume, forming a solid saltcake and a concentrated supernatant salt solution in the tanks.

Ion exchange/Ion exchange resin
The process by which salts present as charged ions in water are attached to active groups on and in an ion exchange resin and other ions are discharged into water, allowing separation of the two types of ions. **Ion exchange resins** can be formulated to remove specific chemicals and radionuclides from the salt solutions in the HLW tanks.

Isotope
See Radionuclide.

Low-level radioactive waste (LLW)
LLW is radioactive waste that does not meet the definition of high-level waste, transuranic waste, spent nuclear fuel, or by-product tailings from processing of uranium or thorium. LLW typically contains small amounts of radioactivity dispersed in large amounts of material. Some LLW requires shielding during handling and transportation to minimize personnel exposure. The SRS generates LLW in both solid and liquid forms.

Mixed waste
Waste that contains both hazardous material, as defined under RCRA, and radioactive source, special nuclear, or by-product material subject to the Atomic Energy Act.

Monosodium titanate
Water-insoluble inorganic substance ($NaTiO_5H$) used to remove fission product strontium and residual actinides (uranium, plutonium) by sorption from HLW salt solutions.

Precipitation (chemical)
Conversion of a constituent in solution into insoluble solid form by chemical or physical means.

Preconceptual Facility design
The preconceptual design phase includes the early articulation of process objectives, selection of process steps, and determination of constraints.

Table 1-1. (Continued).

Radiolytic decomposition
A physical process in which a compound is broken down into simpler compounds or elements from the absorption of sufficient radiation energy to break the molecular bonds.

Radionuclide/Isotope
A radionuclide is an unstable isotope that undergoes spontaneous transformation, emitting radiation. An isotope is any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number), but different numbers of neutrons, so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable, carbon-14 is radioactive).

Reagent
Substance used in a chemical reaction to detect, measure, examine, or produce other substances.

Resin
See Ion exchange.

Salt
Salt components of the HLW consist of water-soluble constituents that do not separate from the solutions in the HLW tanks. The salt components consist principally of sodium nitrate, with radionuclide contents being mainly isotopes of cesium and technetium.

Saltcake
Solid, crystalline phase of the salt component in HLW tanks that forms as a result of dewatering evaporation of the supernatant.

Salt supernatant
Highly concentrated solution of the salt component in HLW tanks.

Sludge
Sludge components of HLW consist of the insoluble solids that have settled to the bottom of the HLW storage tanks. Radionuclides present in the sludge include fission products (such as Sr-90) and long-lived actinides.

Small Tank Tetraphenylborate Precipitation
A technology alternative for processing HLW salt solution to remove radioactive cesium by precipitation as an insoluble tetraphenylborate salt concurrently with removal of radioactive strontium and actinides by sorption onto monosodium titanate. The process would be carried out by continuous reaction in small process vessels to limit benzene formation caused by tetraphenylborate decomposition. These solids are vitrified in the Defense Waste Processing Facility and the remaining low-activity salt solution is immobilized in grout and disposed of as saltstone in onsite vaults.

Sorbent
A material that sorbs another substance; (i.e., that has the capacity or tendency to take up the substance by either absorption or adsorption).

Sodium Tetraphenylborate
Organic reagent used in tetraphenylborate precipitation process for removal of radioactive cesium from HLW salt solution. Chemical formula for sodium tetraphenylborate is $Na(C_6H_5)_4B$.

Tetraphenylborate Precipitation
Process used to separate cesium constituents from HLW salt solution by formation of insoluble solids. The process is projected for use in the Small Tank Precipitation salt processing alternative.

Table 1-1. (Continued).

Vitrify/Vitrification

The process of converting the high-level liquid nuclear waste currently stored at the SRS into a solid glass form suitable for long-term storage and disposal. Vitrification is the preferred option for immobilizing high-level radioactive liquids into a stable, manageable form for disposal in a geologic repository.

a. See also Glossary of Terms Used in DOE NEPA Documents (DOE 1998c).

References

DNFSB (Defense Nuclear Facilities Safety Board), 1996, Defense Nuclear Facilities Safety Board Recommendation 96-1 to the Secretary of Energy, pursuant to 42 U.S.C. § 286a(a)(5) Atomic Energy Act of 1954, as amended, John Conway, Chairman. Available at http://www.dnfsb.gov/recommend/96-1.htm. Accessed June 1, 1999.

TC DNFSB (Defense Nuclear Facilities Safety Board), 2001, Defense Nuclear Facilities Safety Board Recommendation 2001-1 to the Secretary of Energy, pursuant to 42 U.S.C. § 286(a)(5) Atomic Energy Act of 1954, as amended, John Conway, Chairman. Available at http://www.dnfsb.gov/recommended/2000-1.pdf. Accessed May 18, 2001.

DOE (U.S. Department of Energy), 1982, *Final Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Final Environmental Impact Statement, Waste Management Activities for Groundwater Protection*, DOE/EIS-0120, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082S, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement, Savannah River Site Waste Management*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Rev. 1, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998a, *DOE/SR Review Team Final Report on the High-Level Waste Salt Disposition Alternative*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998b, *Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options*, DOE/EIS-0082-SA-03, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998c, *Glossary of Terms Used in DOE NEPA Documents*, Office of NEPA Policy and Assistance, Washington, D.C.

DOE (U.S. Department of Energy), 2000a, "Additional Research and Development (R&D) of Caustic Side Solvent Extraction (CSEX) Alternative." Letter from R. Schepens to W. G. Poulson, Westinghouse Savannah River Company, Aiken, South Carolina, February 15.

DOE (U.S. Department of Energy), 2000b, *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, Savannah River Operations Office, Aiken, South Carolina.

GAO (General Accounting Office), 1999, *Nuclear Waste – Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work*. GAO/RCED-99-69, Washington, D.C.

NAS (National Academy of Sciences), 1999, "Interim Report on Technical Review of Alternatives for Processing High-Level Radioactive Waste Salt Solution at the Savannah River Site." Letter from M. Levinson and G. Choppin to E. J. Moniz, U.S. Department of Energy, Washington, D.C., October 14.

NAS (National Academy of Sciences), 2000, *Alternatives for Processing High-Level Waste Salt at the Savannah River Site*. National Academy Press, Washington, D.C.

NAS (National Academy of Sciences), 2001a, *Radionuclide Separation Processes for High-Level Waste at the Savannah River Site.* Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site. National Academy Press, Washington, DC. TC

NAS (National Academy of Sciences), 2001b, *Research and Development on a Salt Processing Alternative for High-Level Waste at the Savannah River Site.* Committee on Radioactive Separation Processes for High-Level Waste at the Savannah River Site. National Academy Press, Washington, DC. TC

WSRC (Westinghouse Savannah River Company), 1996, *Approved Site Treatment Plan,* WSR1-TR-94-0608, Rev. 4, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *High-Level Waste Salt Disposition Systems Engineering Team Final Report*, WSR1-RP-98-00170, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *High-Level Waste Tank Space Management Team Final Report*, WSR1-RP-99-00005, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report*, WSR1-RP-99-00007, Aiken, South Carolina.